

Context effects on grip-force during pseudo-verbs processing in action denoting sentences

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Introduction

Although motor activation during action-word-processing has received considerable attention, effects of the linguistic context of such activity have largely been overlooked. To assess how flexible and context dependent motor activation during word processing may be, we experimentally tested the impact of action denoting sentences on this activation during the processing of PSEUDO-VERBS: pseudo-verbs are non-sense artificial lexical units that respect the phonological and morphological restrictions of a particular language (French in this study). The goal of the present study is to explore whether motor brain structures that can be called upon during action word processing can be also recruited by pseudo-verbs processing when the best fit for this unknown word in a given context is an action meaning. To assess the role of the linguistic context on lexically induced motor activity we utilized a novel experimental technique developed in our lab (Frak et al., 2010; Aravena et al., 2012), i.e. a grip-force sensor (ATI mini-40) that captures online motor effects of language processing.

Methods

Participants

All of the participants were French undergraduate students (18 to 35 years old; mean age = 22.9, SD = 5.4) and right-handed (Edinburgh Inventory definition), with normal hearing and no reported history of psychiatric or neurological disorders. Twenty-one subjects (including 12 females) participated in this study. Two participants were eliminated from the analysis due to weak signal throughout the experiment.

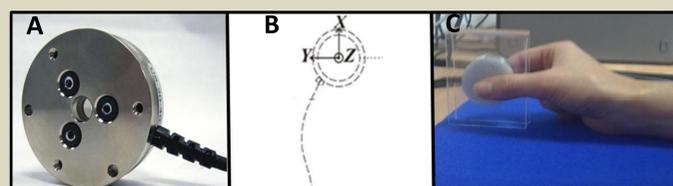


Fig 1: (A) Grip-force sensor (ATI mini-40). (B) 3-axis of load cell. (C) Hand position throughout the experiment.

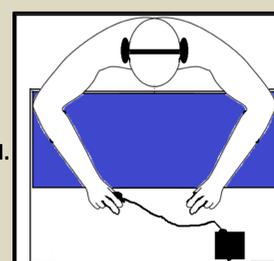


Fig. 2: Experimental setting.

Apparatus In order to quantify online measures of subtle grip force modulation, we used a grip-force sensor (ATI mini-40) with a 3-axis load cell (see Figure 1).

Procedure

The participants were requested to hold the cell with a prefixed force amount to hold it in a nonchalant manner. They were instructed to listen to the spoken sentences. Their task was to silently count how many sentences contained the name of a country.

Stimuli

A total of 148 French sentences served as stimuli (see Table 1). Ten were distractor sentences containing a country name. The data from the trials using the distractor sentences were not included in the analysis. Thirty-seven target-action verbs, 37 pseudo-verbs and 37 non-action verbs were embedded into action contexts. Action predictability were controlled. Action predictability was defined as how easy it was to predict from sentential context that an ensuing word was a manual action verb.

All of the action verbs denoted actions performed with the hand (e.g., scratch or throw). Three different action contexts were created to avoid repetition between conditions and were randomized in 3 lists. Finally, 37 non-action verbs were embedded into non-action contexts.

Condition	Sentence	English Approximate Translation
Action sentence - Action verb	Avec son stylo noir, Pierre <u>signe</u> le contrat.	With his black pen, Pierre <u>signs</u> the contract.
Action sentence- Pseudo-verb	Avec son stylo noir, Pierre <u>capame</u> le contrat .	With his black pen, Pierre <u>capames</u> the contract.
Action sentence- Non-action verb (control)	Avec son stylo noir, Pierre <u>projette</u> de signer le contrat.	With his black pen, Pierre <u>plans</u> to sign the contract.
Non action sentence- Non action verb	La tête dans les nuages, Julie <u>rêve</u> de faire le tour du monde.	With the head in the clouds, Julie <u>dreams</u> to travel around the world.

Table 1. Example of stimuli used in the experiment

Results

A test against the baseline revealed a significant increase in the grip-force for the Action-verb condition in two time windows (320-520 ms [$p=0.016$] and 520-800 ms [$p=0.017$]) and for the Pseudo-verbs condition in the last time windows ($p = 0.054$). No significant effects against baseline were observed for the Non-action condition or for the Control condition. Analysis of Variance (ANOVA) over two defined time windows revealed a significant effect of target word condition in both windows [$F(3,54) = 2.78; p < 0.04$], [$F(3,57) = 3.02; p < 0.03$, respectively]. Post hoc comparison yield significant differences between Action vs. Non Action in both windows ($p < 0.01; p = 0.01$, respectively) and between Action vs Control ($p < 0.02; p < 0.01$). No differences between Action and Pseudoverbs were obtained ($p = 0.17; p = 0.27$, respectively). A tendency towards significance ($p = 0.08$) was observed for Pseudo-verbs vs. Control condition in the last time window.

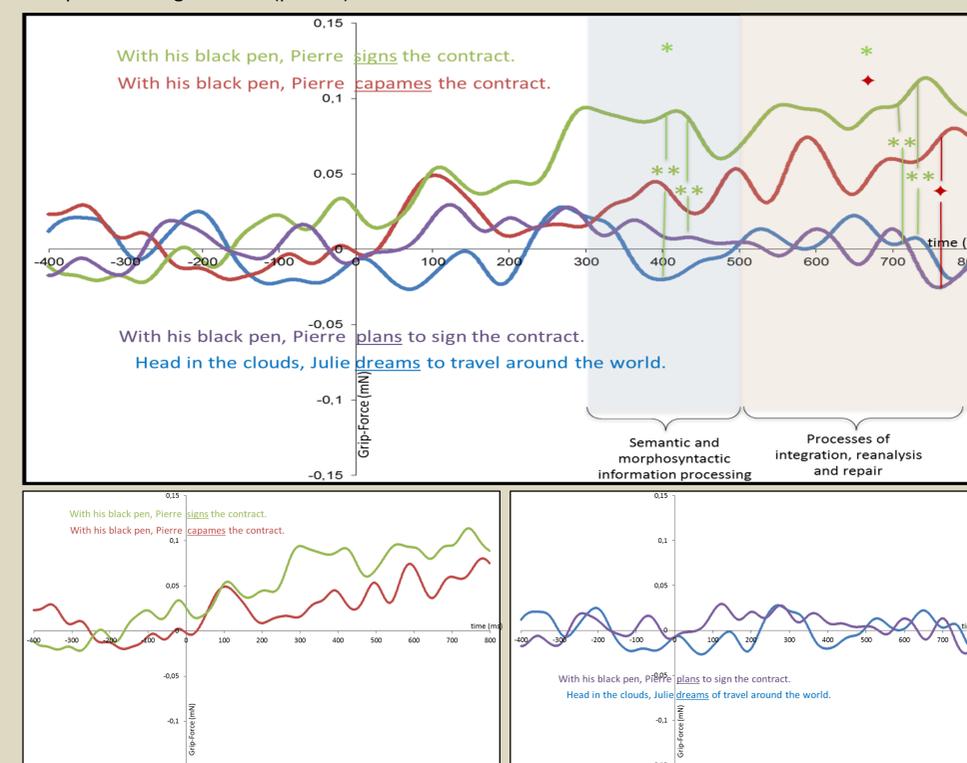


Fig. 3: **Top panel:** Time windows of significant grip-force increase with respect to baseline for the Action and Pseudo-verbs conditions are marked by a colored background. In both windows the Action-verb condition differed significantly from the Non-action and the Control condition. A tendency towards significance for Pseudo-verbs vs. Control condition was also observed in the last time window (♦). **Left bottom panel:** Grip-force modulation for Action and Pseudo-verbs. **Right bottom panel:** Grip-force for Non-action and Control words.

Conclusion

The similar grip-force modulation observed during the processing of Action verbs and Pseudo-verbs embedded in action contexts suggests that language induced motor activity is flexibly tailored to context and that semantic features of concepts are dynamically recruited depending on the given background (see also Willems and Casasanto, 2011). Our findings oppose a simple associative learning model that assumes that language-induced motor activation results as a consequence of the word learning-dependent neural coupling between the language areas and the motor areas (Pulvermüller, 2005). Since our pseudo-verbs meet phonetic, prosodic, and phonological properties of French, they represent potential meaningful words (unknown to the participant), and thus participants use context to infer the semantics of the unknown word to immediately assign meaning to the sentence. Since in the present study, context was manipulated so that the word that fitted best were an action verb (predictability), pseudo-verbs were processed as if they were action verbs, at least regarding the parts of lexical-semantic representations that might be located in motor structures. Answering the question of whether language-induced motor activation is context-dependent or fixed to action concepts will help in evaluating the alternative accounts for the action-language.

References

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